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Case report

Dental fracture and chocolate candies: Case report

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ABSTRACT

A complaint by a customer to a food company claimed that the consumption of a chocolate candy fractured his anterior teeth, due to its hard consistency. Fragments of the fractured teeth and the chocolate candy that supposedly caused it were collected, examined and photographed. Fragments presented caries, large restorations, and suggested previous endodontic treatment. To evaluate causation, the food company requested a laboratory analysis, which simulated the human bite on chocolate candies of the same brand. Human teeth were assembled in a simulating device of masticatory functions of apprehension and incision. Teeth used were either sound or with non-restored endodontic accesses, to simulate previous conditions of the collected fragments. Twenty chocolate candies, cooled in a freezer to 0 °C for 2 h were used as test foods, and were positioned between the teeth of the device at the moment of the test. The set was put in a dynamometer, programmed to apply increasing forces (rate of advance of 5 mm/min), until rupture (either of the specimen or of the teeth). The applied force, in N, at the time of fracture was recorded and analyzed. The average force to fracture the test food was 233.23 N. No tooth was fractured in the experiment. Forces ranging from 191.3 to 275.2 N, applied to chocolate candies were not sufficient to neither fracture human teeth nor cause any structural damage. It was concluded that the dental fracture occurred because of previous oral health conditions of the customer.

1. Introduction

The food industry is obliged to commercialize products that do not cause risks to customer's health. To the customer, if a defective food is consumed, it may cause injuries like infections, asphyxia and hazards to the digestive and the stomatognathic systems (injuries of oropharyngeal and soft tissues, tooth fractures, fractures of dental prosthetics and its consequences). To the industry, this may cause undesired situations, like downtime on production lines to investigate the manufacturing defects, complaints that may tarnish the company's reputation, product recalls and lawsuits.

2. Case report

A food company was called by a customer, who claimed to have broken his upper incisor teeth when eating their chocolates. The customer kept the dental fragments and the bitten chocolate candy. He affirmed to have had a hemorrhage due to the fracture, and that as he also suffered from a previous thrombosis, he had to be hospitalized. The customer demanded compensation for the expenses with drugs, medical and dental care. The remaining fragments of the fractured teeth were collected and sent to the company.

The company requested urgently that the complainant visited a Dentist and provided the technical reports and other documents necessary to evaluate the damages. The delivery of these documents was always postponed by the complainant, which alleged various different reasons, and never actually happened.

Irritated because the analysis of the case would not go further unless proper documentation was provided, the complainant affirmed he could cause major damages to the company's credibility, in a veiled threatening attitude.

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The company sent the tooth fragments and the chocolate candy to laboratory analysis. The company's documents with the records of the complaint were also sent.

2.1. Collected material

Materials collected for analysis were a chocolate candy, measuring $3.3 \times 2.3 \times 1.8$ cm^3 with bitemarks on both sides and two dental fragments. The fragments were found to be remains of upper incisor teeth with presence of caries and large restorations, suggesting that the teeth could have had undergone endodontic treatment previously to the fracture (Fig. 1). As dental data was never sent by the customer, this finding could not be confirmed.

2.2. Characteristics of specimens (test foods)

Twenty chocolate candies (of the same brand of the collected candy) were sent by the company for testing.[1] Tests were not performed with the specimens at room temperature (24 °C), because the chocolate could be softer than normal. Specimens were stored in a freezer for 2 h, lowering their temperature to about 0 °C. The chocolate candies achieved uniform hardness (higher than the usual). The specimens were removed of the freezer separately, only moments before being tested, therefore reaching temperatures of about 2 °C at the moment of analysis.

2.3. Apprehension and incision simulator device

An apprehension and incision simulator device was developed. Human and artificial teeth were placed on an acrylic resin base. The device had an arch of upper teeth, formed by teeth 11, 12, 21 and 22 (ISO 3950 – FDI notation). Teeth 12 and 21 were sound, while teeth 11 and 22 had their crowns ground open with accesses for endodontic treatment (removal of resistant areas of the tooth, to simulate oral conditions suggested by the fragments). Tooth 11 was positioned 2 mm above the incisal plane, so that it would be the first tooth to touch the specimens. An unfavorable situation was simulated, with an isolated and weakened tooth being the first to touch and press food during apprehension and cut. In the lower arch, human teeth 31, 32, 41 and 42 were placed. Accesses for endodontic treatment were done in teeth 32 and 42. The lower teeth were mounted to simultaneously receive loads of similar values, providing a uniform cutting line.

To simulate a normal occlusion (upper incisors touching the lower incisors and lower canines in occlusion), artificial lower canine teeth, less resistant than natural teeth, were also placed. The device was assembled to obtain incisal plane parallel to the ground when specimens were placed between the dental arches. This was achieved by positioning is a bubble level on top of the device.

Assembly purposely positioned the upper teeth at a markedly oblique angle in relation to the long axis of the lower teeth. When dental arches crossed each other (corresponding to the lifting movement of the mandible to close the mouth and cut food), the focus of efforts would not be on the long axis of the upper teeth, but in its transverse direction. Thus, the forces applied would be dispersed in the direction in which the teeth are less resistant[2] (Fig. 2).

2.4. Dynamometer settings

An Instron® dynamometer (Maryland, USA) was used. It was calibrated to apply increasing vertical forces to maintain a rate of advance 5 mm/min. The specimens were placed between the dental arches and the dynamometer was triggered (Fig. 3). Increasing forces were applied and sequentially registered by the equipment. When there was a rupture (whether of a tooth or a specimen), the machine was set to stop and display the force applied, in N (Fig. 4).

2.5. Test results

Results for all tests are shown in Table 1. An average of 233.2 N was needed to fracture all specimens by shear. The lowest force required to fracture the specimen was recorded on test 2 while the highest was on test 10. No tooth fractured due to the tests.

3. Discussion

The stomatognathic system performs mastication, and one of its stages is apprehension and cutting of food by incisor teeth.[3,4] During mastication, when mechanoceptors of the periodontal ligament are stimulated, the jaw lowers in a reflex response, through muscular inhibition. It is hypothesized that this is a response of normal mastication or even a protective mechanism.[5-7] Information about mechanical properties of food is also obtained from the stimulation of these receptors and helps modulate mastication.[8–10] Since the fine motor coordination of the jaw (strength, duration, muscular impulse and active pressure of the bite) is related to these structures,[11–15] when they are removed (e.g., tooth extraction), other types of periodontal receptors do not compensate for this loss.

Different regions of the mouth present different bite forces, according to the group of teeth used in mastication. In the region of incisors, this force may vary from 89 to 111 N. The strength of bite of men is generally higher than those of women and in adults the force is greater than in children.[16] Endodontically treated central and lateral incisors, when taking oblique forces, usually fracture at loads of 705 and 894 N, respectively.[17] The results comply with

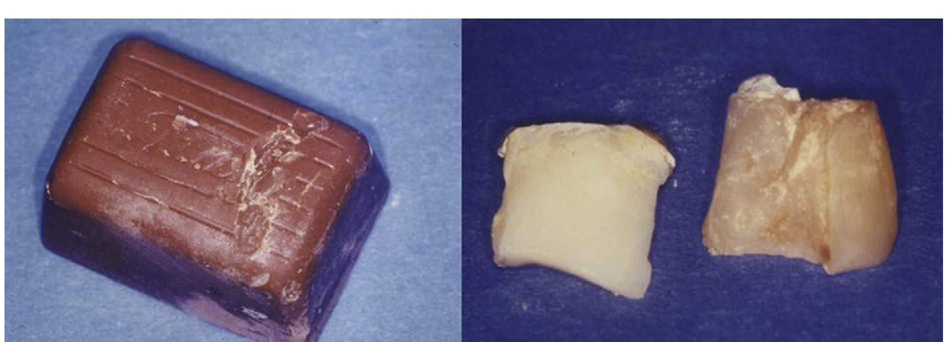

Fig. 1. Chocolate candy that supposedly caused the fracture (left) and dental fragments collected by the company (right).

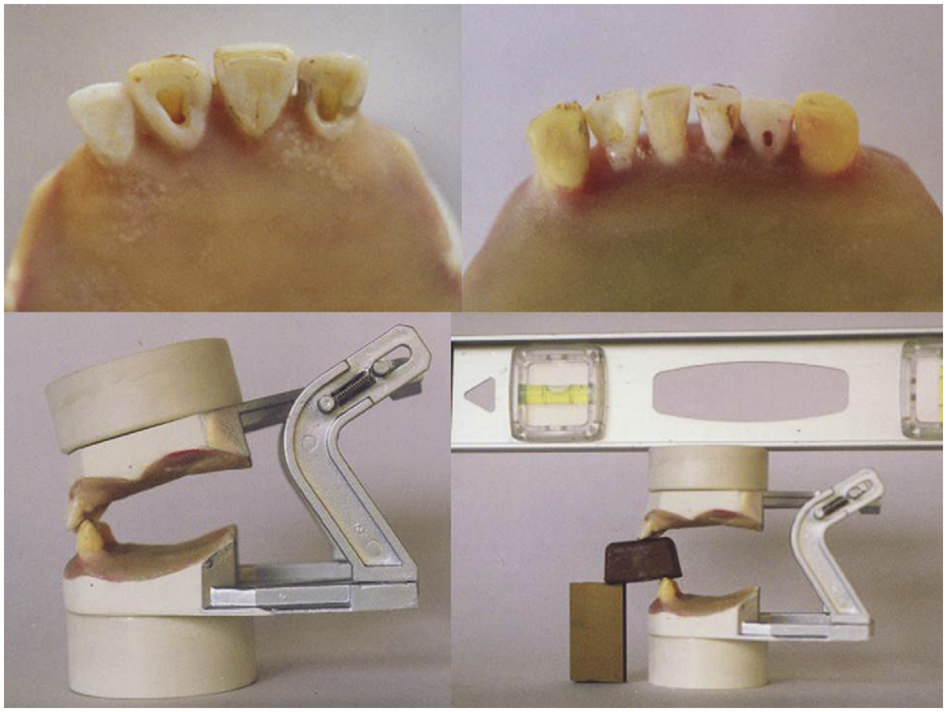

Fig. 2. Apprehension and incision simulator device. Teeth used were sound or prepared with non-restored endodontic accesses. Lower artificial canine teeth were also used to simulate the dental contacts during mastication (upper left and right, lower left). Mounting of the teeth caused incision efforts to be applied transversely to the long axis of the teeth when the test food was placed in the device (lower right).

these findings, as forces were higher than the usual strength of bite of men (due to absence of physiological compensators, such as the periodontal ligament) and lower than the oblique force needed to fracture endodontically treated incisors.

Not a single tooth was fractured in the tests, and some important aspects must be considered. The teeth used in the experiment were stored in glass jars without fixation, becoming dehydrated and more susceptible to fractures. Furthermore, it is not possible to

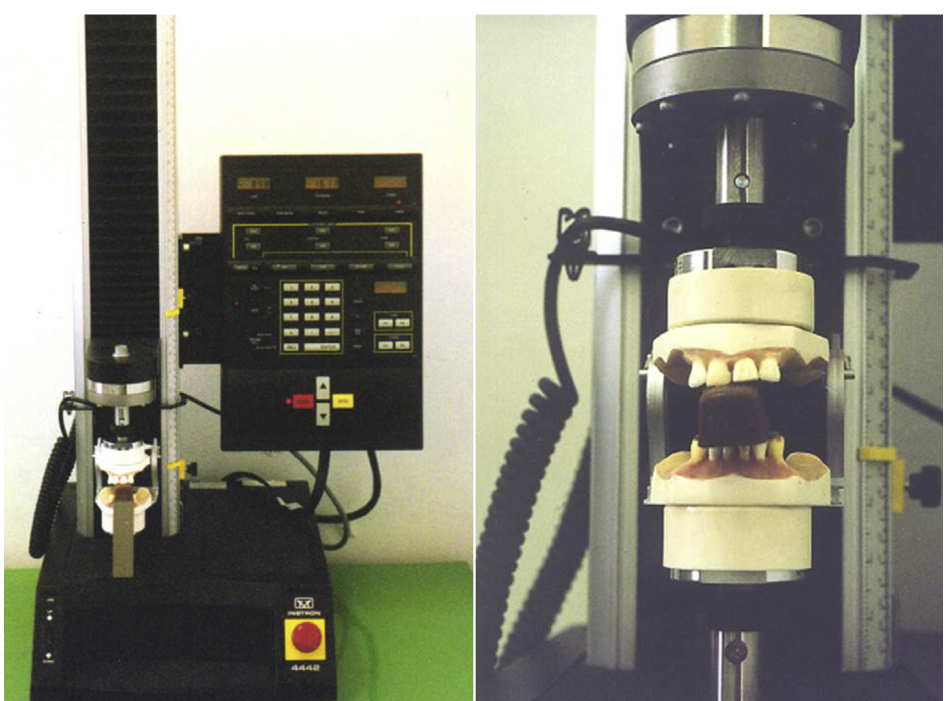

Fig. 3. Set placed in the dynamometer.

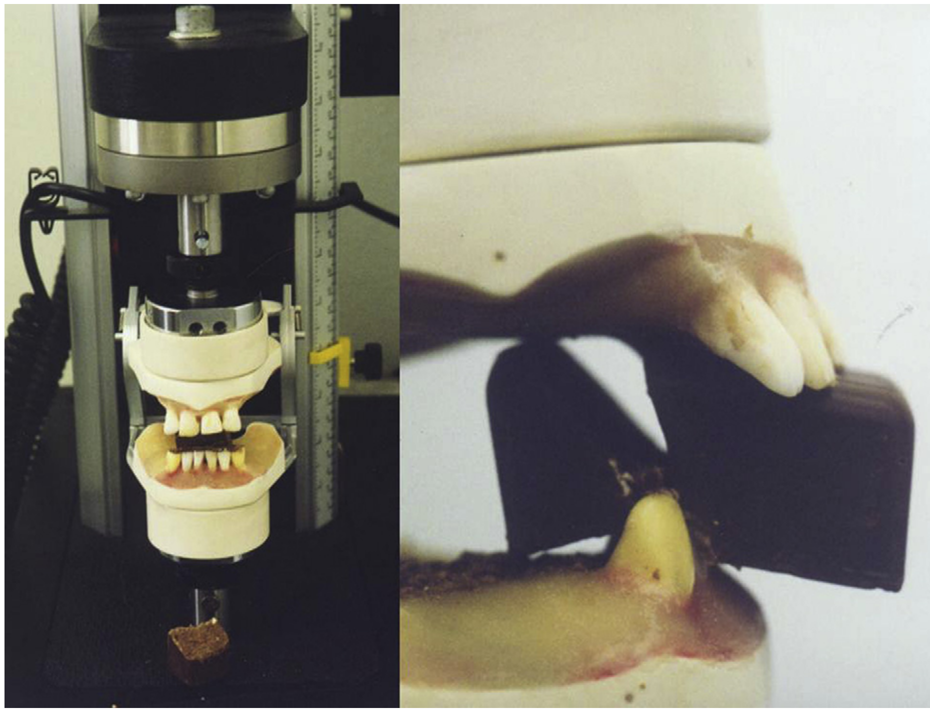

Fig. 4. Moment of fracture of the test food and record of the applied force.

reproduce *in vivo* tooth implantation conditions in laboratory. The teeth in their *alveoli* have anatomical and physiological features that control the load applied on teeth (e.g. periodontal ligament and mechanoceptors).[5,7,8,11] As the teeth were embedded in acrylic resin, the efforts could not be dispersed or compensated as *in vivo*. Thus, almost the entire load was applied exclusively on the assembled teeth.

In both sound and endodontically treated and crown-rehabilitated upper incisors, the angle of application determines the force needed to fracture a tooth. The more parallel to the long axis of the tooth, more force is required to fracture it, while in more oblique angles less force is required to fracture a tooth.[2,18] It means that when forces are applied more parallel to the long axis of the tooth (less oblique angles – normal anatomical incisor position during biting), this direction favors their proper dissipation, from enamel to dentine, through periodontal ligament, alveolar bone and skull bones. On the other hand, when forces are applied at more oblique angles (teeth with malocclusion and/or horizontal loss of alveolar bone), their distribution does not occur in an effective way, enhancing the risk of fracture due to unfavorable direction of biomechanical dissipation (against normal anatomical features of incisor teeth). Thus, teeth resist less to fracture, since masticatory forces are not well dissipated. Factors such as presence and extent of restorations or unfavorable periodontal conditions may influence the risk of tooth fracture.[3] Loss of horizontal alveolar bone[19] and quantity and location of remaining tooth[20] may also influence this risk. Although periodontal conditions, loss of alveolar bone and specific quantities and location of remaining tooth were not simulated, all other conditions of the mounted teeth were favorable to the occurrence of dental fractures. As the complainant did not send his dental data, tests performed attempted to simulate the oral conditions of the claimant based only on the sent dental fragments, with significant portions of sound structure being removed for endodontic access in the tested teeth. In addition, these teeth were subjected to unfavorable conditions, mounted on an angulation which decreases the force required to fracture them, and did not have aid of anatomical and physiological mechanisms to dissipate these loads. Furthermore, the consistency of the specimens was harder than usual, due to cooling. The tests showed that even in less resistant teeth, there is no risk of fracture when one bites chocolate.

It was concluded that if the fracture actually occurred at the time of the bite, it was mostly because of the pre-existing oral conditions of the teeth, which were far structurally compromised due to the presence of caries, large restorations and a probable access to endodontic treatment, therefore unable to resist to moderate loads. This laboratory analysis presented a suggestion of methodology for assessing dental fracture resistance to test foods, provided the company a good way to prove its products were safe for consumption and guard itself against a lawsuit, given the veiled threatening and money-seeking behavior of the claimant.

Table 1
Values of forces applied at the time of fracture of specimens.

Test	Applied force (N)	Test	Applied force (N)
1	224.8	11	236.2
2	191.3	12	191.9
3	257.9	13	249.7
4	242.2	14	234.4
5	255.3	15	241.9
6	244	16	272.5
7	228.2	17	209.6
8	196.8	18	216.7
9	263.1	19	218.8
10	275.2	20	214.1
		Average	233.2

Ethical approval

None.

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Conflict of interest

We the authors of the paper entitled “Dental fracture and chocolate candies: case report” state that there is no conflict of interest regarding this work.

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